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Patent Department
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EXAMINER	
ENG, MARSHALL S	
ART UNIT	**PAPER NUMBER**
2133	

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Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 09/858,358	Applicant(s) YEDIDIA ET AL.	
	Examiner Marshall S Eng	Art Unit 2133	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-17* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-7,12, 15, and 17* is/are rejected.

7)☒ Claim(s) *1, 7-11, 13, 14, and 16* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *16 May 2001* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Drawings

1.1 The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description: reference 100 of Figure 1 as mentioned on line 6 of page 4.

1.2 The drawings are further objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description: reference 900 of Figure 9 as mentioned on line 12 of page 16, on line 3 of page 18, and on line 17 of page 27.

1.3 The drawings are further objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description: references 301-305 of Figure 3 as mentioned on line 11 of page 25.

1.4 The drawings are further objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description: references 601 and 602 of Figure 6 as mentioned in lines 19 and 20 of page 26.

1.5 The drawings are further objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description: references 811, 812, and 813 of Figure 8 as mentioned on lines 19 and 20 of page 28.

1.6 The drawings are further objected to as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference sign(s) not mentioned in the description: references 801, 802, and 803 of Figure 8.

1.7 The drawings are further objected to because the value of p21 in Figure 3(e) is incorrect. The variable p_{21} should be equal to $2x^2-x^3$ as in line 3 of page 20.

1.8 The drawings are further objected to because the value of variable p_{21} in Figure 3(e) is incorrect. Variable p_{21} should equal $2x^2-x^3$ as stated in line 3 of page 20.

A proposed drawing correction or corrected drawings are required in reply to the Office action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

Specification

2.1 The disclosure is objected to because of the following informalities: the phrase "this method is important background of the method" on lines 11-12 of page 3 is unclear. A possible suggested change is "this method is important background information for the method."

2.2 The disclosure is further objected to because of the following informalities: the phrase "check-to-bit" on line 24 of page 5 should apparently be "check-to-variable."

2.3 The disclosure is further objected to because of the following informalities: the word "checks" on line 9 of page 7 should apparently be "check nodes."

2.4 The disclosure is further objected to because of the following informalities: the phrases "message q_{ai}" and "q_{ai} messages" on lines 16 and 22 of page 7 should

apparently be "message m_{ai}" and "m_{ai} messages." The variable q_{ai} represents the probability that m_{ai} is an erasure, and is therefore not representative of a message.

2.5 The disclosure is further objected to because of the following informalities: the equation for p_{42} is incorrect on line 13 of page 9. The formula for p_{42} should be $p_{42} = x$.

2.6 The disclosure is further objected to because of the following informalities: the equation for q_{11} is missing on page 9. The formula for q_{11} should be $q_{11} = p_{21}$.

2.7 The disclosure is further objected to because of the following informalities: the equation for q_{24} is incorrect on line 17 of page 9. The formula for q_{24} should be $q_{24} = 1 - ((1-p_{32})(1-p_{22}))$.

2.8 The disclosure is further objected to because of the following informalities: the phrase "parity checks" on line 24 of page 10 should apparently be "check nodes."

2.9 The disclosure is further objected to because of the following informalities: a comma is apparently missing between the words "nodes" and "renormalize" in line 4 of page 17.

2.10 The disclosure is further objected to because of the following informalities: the variable "b_l" on line 1 of page 18 should apparently be "b_i". (It should be a lower case 'i').

2.11 The disclosure is further objected to because of the following informalities: the word variable on line 4 of page 18 in the phrase "target variable node" is apparently unneeded. The phrase should read "target node."

2.12 The disclosure is further objected to because of the following informalities: the phrase "the farthest" on line 7 of page 18 should apparently be replaced with "a."

2.13 The disclosure is further objected to because of the following informalities: the phrase “variable node” on line 7 of page 18 is apparently missing the variable “i.” It should read “variable node i.”

2.14 The disclosure is further objected to because of the following informalities: the phrase “the target node i” on line 8 of page 18 should apparently be “check node a.”

2.15 The disclosure is further objected to because of the following informalities: the phrase “leaf node” on line 8 of page 18 is apparently missing the word “variable.” The phrase should read “leaf variable node.”

2.16 The disclosure is further objected to because of the following informalities: the phrase “target node i” on line 10 of page 18 should apparently be “check node a.”

2.17 The disclosure is further objected to because of the following informalities: the phrase “target node” on line 17 of page 18 should apparently be “variable node.”

2.18 The disclosure is further objected to because of the following informalities: the phrase “loopy graphs” on lines 25-26 of page 18 should apparently be “graphs with loops.”

2.19 The disclosure is further objected to because of the following informalities: the phrase “node b_i” on line 1 of page 19 should apparently be “b_i.”

2.20 The disclosure is further objected to because of the following informalities: the variable p in line 14 of page 19 should apparently be p_{11}.

2.21 The disclosure is further objected to because of the following informalities: the initial values of b_1, b_3, and b_4 on page 19 are not given. Also the initial value of $b_2 = 0$ is incorrect. The initial values of $b_1 = b_2 = b_3 = b_4$ should all be equal to x.

2.22 The disclosure is further objected to because of the following informalities: the phrase "940 a node" on line 20 of page 20 is apparently missing the word "variable." It should read "940 a variable node."

2.23 The disclosure is further objected to because of the following informalities: the phrase "attached to node i" on line 23 of page 20 is apparently missing the word variable. It should read "attached to variable node i."

2.24 The disclosure is further objected to because of the following informalities: the phrase "for two messages" on line 19 of page 22 is apparently missing the phrase "independent" or "mutually exclusive." The phrase should read "for two independent messages" or "two mutually exclusive messages."

2.25 The disclosure is further objected to because of the following informalities: the word "an" apparently is not needed in the phrase "associated an erasure" on line 9 of page 25.

2.26 The disclosure is further objected to because of the following informalities: the phrase "$_{mai}$" on lines 2 and 13 of page 30 apparently should be "m_{ai}."

2.27 The disclosure is further objected to because of the following informalities: the phrase "then the consistency condition means the means μ of these distributions are related to the variances σ^2 by $\sigma^2 = 2\mu$" on lines 20-21 of page 30 should be rephrased to be made clearer. A possible suggestion is "then the consistency condition means that the means, μ, of these distributions are related to the variances σ^2 by $\sigma^2 = 2\mu$."

2.28 The disclosure is further objected to because of the following informalities: the variable "h_l" on line 2 of page 32 should apparently be "h_i."

2.29 The disclosure is further objected to because of the following informalities: the second phrase “at least” on line 20 of page 34 is not needed.

2.30 The disclosure is further objected to because of the following informalities: The phrase “iteratively renormalizing” of the independent claim 1 does not have a clear and concise meaning from the specifications. Two meanings can be taken from the specifications for the phrase. One definition for “iteratively renormalizing” is given in lines 5-15 of page 13. In this definition, “iterative renormalization” is defined as a series of steps until a threshold is reached. The steps consist of: “a particular variable node is selected as a target node, and a distance between the target node and every other node in the bipartite graph is measured. Then, if there is at least one “leaf” variable node, renormalize a leaf variable node farthest from the target node, otherwise renormalize a leaf check node farthest from the target node and having fewest directly connected check nodes. ... When the number of nodes in the graph is less than the predetermined threshold, the decoding failure rate for the target node is determined exactly.” One skilled in the art would therefore define “iteratively renormalizing” as a method of selecting a target node, determining the farthest nodes from the target node, and renormalizing the farthest nodes until a threshold of nodes is reached.

A second definition of iteratively renormalizing is given when the phrase “renormalize” is described/defined as “iteratively eliminate” on lines 22-23 of page 15. It would therefore be reasonable for one skilled in the art to define “iteratively renormalizing” as iteratively, iteratively eliminating.

While it is understood that the appropriate definition "iteratively renormalizing" is the first one, the uncertainty that is raised by defining renormalize as iteratively eliminate should be cleared up. An alternate definition or alternate choice of words for renormalize should be given.

Appropriate corrections are required.

Claim Objections

3.1 Claim 1 is objected to because of the following informalities: the phrase "comprising" or "comprising of" or an equivalent statement is missing before the steps of the method are listed.

3.2 Claim 7 is objected to because of the following informalities: the variable "q_{ia}" on line 4 should apparently be "q_{ai}."

3.3 Claim 7 is further objected to because of the following informalities: the ":" at the end of the phrase "check nodes a:" should apparently be a ";."

3.4 Claim 16 is objected to because of the following informalities: the word "generation" in line 3 of claim 16 should apparently be "generating."

3.5 The specification is objected to as failing to provide proper antecedent basis for the claimed subject matter. See 37 CFR 1.75(d)(1) and MPEP § 608.01(o). Correction of the following is required: in line 1 of claims 13 and 14 the phrase "the transmission channel" lacks antecedent basis. The phrases should be replaced with "a transmission channel."

3.6 Claim 14 is objected to because of the following informalities: the claim must end in a period as per MPEP 608.01(m).

Appropriate corrections are required.

Claim Rejections - 35 USC § 103

4.1 The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

4.2 Claims 1-4, 7, and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tanner (US Patent # 4,547,882) in view of Rüger (Efficient Inference and Learning in Decimatable Boltzmann Machines, February 1997).

4.3 In regards to claim 1, Tanner substantially teaches

> "a method for evaluating an error-correcting code for a data block of a finite size"

In lines 57-65 of column 3, Tanner teaches of providing "a technique ... for implementing codes having quality comparable to, and in some case, superior to, that of

the best known codes." By stating that his new codes are comparable to or superior to prior art codes, Tanner is clearly evaluating his codes with the same criteria used to evaluate the best-known codes. Tanner also teaches of a finite graph in Fig 10(b) in lines 42-43 of column 6. Since the graph is a finite graph, the related code will obviously be a finite code, which yields data blocks of finite size.

> "defining an error-correcting code by a parity check matrix"
>
> "representing the parity check matrix as a bipartite graph"

In lines 35-52 of column 8, Tanner teaches of "a linear code ... satisfying the matrix equation H·C = 0 where H is an N-k by N matrix of elements from some field, and C is a 1 by N vector of field elements. Each row of the matrix constitutes a generalized parity check subcode on the digits corresponding to non-zero entries in the matrix. The[This] leads immediately to an interpretation of the code as a bipartite graph of the type given above. For binary codes, the H matrix represents a version of the connection matrix for the bipartite graph." The matrix H is a parity check matrix (since its rows are parity check subcodes). This matrix therefore defines the linear code. The matrix is also representable by a bipartite graph because it is a version of a connection matrix (for a bipartite graph).

Tanner does not teach the step of

> "iteratively renormalizing a single node in the bipartite graph until a predetermined threshold is reached."

Rüger in an analogous art teaches in lines 3-5 of page 12 of decimating " all non-bias nodes ... until no further nodes can be decimated." Since decimation is calculating

the interaction of two nodes by reducing the rest of the network in such a way that the interaction is not disturbed (lines 3-5 of page 3), it is a similar process to applicant's iterative renormalization. Since Rüger teaches of decimating all non-bias nodes until no more nodes can be decimated, the threshold for Rüger's method is set so that it stops when there are no more decimatable nodes.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to adapt Tanner's method to include Rüger's decimation teaching so as to allow the creation of simpler codes without loosing a large degree of effectiveness. Tanner suggests in lines 10-15 of column 3 that one can simplify encoding and decoding process by using simpler, but less effective, codes. Rüger's decimation reduces the overall size/number of nodes without affecting the overall interaction of the nodes. This effectively does not significantly change the characteristics of the entire graph (edge weights). By inserting Rüger's teachings into Tanner's, one skilled in the art would be able to produce simpler codes through decimation without loosing a large amount of the code's effectiveness. One skilled in the art would want to insert Rüger's teachings into Tanner's so as to take advantage of Tanner's error-correcting coding system by using a computationally simple, yet highly effective code.

4.4 <u>In regards to claim 2</u>,

Tanner teaches of the limitations of claim 1 as above.

Tanner does not teach of

"the predetermined threshold is a minimum number of remaining nodes"

Rüger in an analogous art further teaches in lines 3-5 of page 12 of decimating " all non-bias nodes ... until no further nodes can be decimated." Since decimation is calculating the interaction of two nodes by reducing the rest of the network in such a way that the interaction is not disturbed (lines 3-5 of page 3), it is a similar process to applicant's iterative renormalization. Since Rüger teaches of decimating all non-bias nodes until no more nodes can be decimated, there is a threshold for Rüger's method to stop when there are no more decimatable nodes; or in other words when the minimum number of nodes left is equal to 1 (only the bias node remains).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to adapt Tanner's method to include the further teachings of Rüger so as to create a state in which the decimation, as taught in claim 1, stops. Rüger, in lines 23-25 of page 11, teaches of "decimating the Boltzmann machine step by step until the trivial Boltzmann machine ... is reached." Rüger further teaches in lines 10-12 of page 3 that the decimation process allows one to compute system values efficiently. By inserting Rüger's further teachings into those of Tanner, one skilled in the art would be able proceed with the decimation process until there are no more decimatable nodes left. One skilled in the art would be motivated to do this so as to be able to decimate nodes so that the resulting Boltzmann machine will yield computationally simpler system value equations than the original non-decimated Boltzmann machine.

4.5 <u>In regards to claim 3,</u>

Tanner teaches of the limitations of claim 1 as above including:

"wherein the bipartite graph includes variable nodes representing variable bits of the data block, and check nodes representing parity bits of the data block"

In lines 5-8 of column 8, Tanner teaches of "one class of nodes, say red, is chosen to represent subcode nodes, the other class to represent digits of the code." Here the subcode nodes are the variable nodes and the digit nodes are representative of the data/variable nodes. Tanner also teaches in lines 42-48 of column 8 that "each row of the matrix constitutes a generalized parity check subcode on the digits corresponding to non-zero entries in the matrix. The leads immediately to an interpretation of the code as a bipartite graph." Since each row is a parity check subcode, each row (and it related check node) will represent a combination of the digits/data/variable bits.

Tanner does not teach the steps of

"selecting a particular variable node as a target node"

"selecting a particular node to be renormalized"

Rüger in an analogous art further teaches in lines 23-28 of page 11 teaches of "decimating the Boltzmann machine step by step until the trivial Boltzmann machine {0} ... is reached." By removing (decimating) nodes until a trivial state is reached, Rüger is iteratively removing nodes until only one node is left – the bias node. This is essentially choosing the bias node as a target node and removing all nodes but the target node. Also, by decimating step by step, Rüger is selecting one node at a time to be

removed/decimated/renormalized. (Also see Figure 3 on page 12 of Rüger to see one node chosen and decimated at a time down to the bias node, 0, only.)

It would have been obvious to one of ordinary skill in the art at the time the invention was made to include the further teachings of Rüger with those of Tanner so as to clearly define an operation order of the decimation process. One skilled in the art would be motivated to do this to make the decimation process more efficient by defining a target/bias node and picking certain nodes to be renormalized. By having a target node and selecting a node to decimate, the process will not waste time inspecting each node individually to see if they are decimated or decimatable.

4.6 In regards to claim 4,

Tanner teaches of the limitations of claim 1 as above, including:

> "measuring a distance between the target node and every other node in the bipartite graph"

Tanner teaches of a characteristic of a "best" graph as being its diameter. In lines 60-65 of column 8, Tanner teaches that "the diameter of the graph is the maximum over all pairs of nodes of the minimum length path connecting the two nodes. It is a measure of the greatest possible separation between two nodes in the graph, hence the term diameter." Applicant's method measures the "distance" between every node and the target node. The applicant defines distance as the minimal number of nodes through which one passes to travel from one node to the other. Therefore, applicant's distance and Tanner's diameter essentially calculate the same values – the maximum distance between any two nodes. Since applicant always tries to choose the

variable/check node farthest from the target node, the applicant is always choosing the node that is of maximum distance away, or in other words always choosing the node that is the relative diameter away, with respect to the bias/target node always being the node where the measurement begins. Although Tanner's graph is not changing, one skilled in the art would easily be able to implement diameter recalculations whenever a node is decimated.

Tanner does not teach the step of

> "if there is at least one leaf variable node, renormalize a particular leaf variable node farthest from the target node, otherwise; if there is at least one leaf check node, renormalize a particular leaf check node farthest from the target node, otherwise; renormalizing a non-leaf variable node farthest from the target node and having fewest directly connected check nodes"

Rüger in an analogous art further teaches in lines 3-8 of page 13 that "decimating node 1 means replacing the weights v_{01} and v_{15} by an additive correction of the weight v_{05} that is given by Corollary 4.2. All other weights remain invariant." Corollary 4.2, which is given on page 11 states that if node $a_1 \neq 0$ is only connected with node a_2 and node 3, then node a_1 can be decimated, and the interaction mediated by a_1 is replaced by the insertion of the effective weight v'_{a2a3}." Rüger also teaches on lines 10-14 of page 12 that "one pragmatic peace [piece] of advice would be to prefer decimating the node among several possibilities whose decimation results in the fewest number of edges."

Since Rüger suggests to decimate the node that would result in the fewest number of added edges, it is clear that if a leaf node were available for decimation, it would be the preferred node to be decimated. Since a leaf node is only connected to one other node, decimating it would result in adding 0 new edges, which is clearly the fewest number of possible edges. Also, it would have been obvious to choose a node that is farthest away from the bias/target node (maximum distance of applicant = diameter of Tanner). Since Rüger teaches that during decimation "all other weights remain invariant" other than the weights of the edges directly connected to the decimated node, it is obvious that one would want to work on the nodes farthest from the bias/target and work in towards the bias/target node. Since all other weights remain invariant, the weights of the edges associated with the bias/target node remain unchanged until the directly connected nodes are decimated and the appropriate additive weight corrections have been applied. Also, it would have been obvious to decimate a non-leaf node if there are no leaf nodes left. As mention before, Rüger suggests to decimate the node that would result in the fewest number of added edges. If there are no lead nodes left, then the non-leaf node that results in the fewest number of added edges should be chosen for decimation. Adding Rüger's other teachings that the weights of the edges associated with the bias/target node remain unchanged until the directly connected nodes are decimated, and it would be obvious to one skilled in the art to choose a non-leaf node (if no leaf nodes exist) and to also choose a non-leaf node that is farthest away from the bias/target node. By choosing a non-leaf node farthest away from the bias/target, the effects of the decimation will only be immediately

seen by the nodes directly connected to the decimated node. Since the decimated node is the relative diameter away with respect to the bias/target node being the origin of the measurement, the effects of the decimation will not reach the bias/target node until nodes directly connected to the bias/target node are decimated and the appropriate additive weigh corrections have been applied.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to include the further teachings of Rüger with those of Tanner so as to further define the operation of the decimation process. One skilled in the art would be motivated to do this to make the decimation process precisely defined. By having the process precisely defined, the process will be able to be implemented in an exact order with expected actions and results.

4.7 In regards to claim 7,

Tanner teaches of the limitations of claim 4 including:

"a transmission channel is a binary erasure channel"

Tanner teaches in lines 30-40 of column 3 of a binary channel where two pre-assigned voltage levels are transmitted. If the received voltage level were midway between V sub 0 and V sub 1, the probability of the unknown signal being a 1 or a 0 would be 0.5. The closer the received voltage is to the V sub 1 and V sub 0 voltage, the higher the probability that it is the digit represented by that voltage. Tanner goes on to teach in lines 41-45 of column 3 that "by taking advantage of the foregoing, the demodulation equipment may provide an additional continuous voltage, or the like, which indicates not only whether a zero or a one was apparently transmitted, but also

the relative likelihood of each." By combining the binary channel with the fact that signals are transmitted with probabilities of correctness/likelihood, Tanner is essentially using a binary erasure channel wherein if a received signal's probability is too low, the signal can be considered incorrect/wrong or lost.

Tanner does not teach of

> "decorating the bipartite graph with numbers p_{ia} representing probabilities of messages from variable nodes to check nodes and with numbers q_{ai} representing probabilities of messages from check nodes to variable nodes"

Rüger in an analogous art teaches of Boltzmann machine structure as being nodes, edges, and weights associated with each of the edges (see lines 25-30 page 3). Rüger goes on to teach in lines 10-14 on page 9 that "an attractive special case [of Boltzmann machines] are networks." The edge weights, can therefore be seen as a cost or some type of quantifier for the communication line (edge). Since a bipartite graph is an undirected graph, it would have been obvious to use two costs/weights per edge to represent different "costs" for each direction of travel. This would be done because in an undirected graph, the cost/weight of an edge may not be the same for each direction of travel. Since an edge can be used for two different directions of travel, it is possible for one direction of travel to "cost" more than the other. As in claim 3 above, nodes represent both the variable and parity nodes. Since the nodes are in a bipartite graph, and the two sets of vertices are the variable and the parity vertices, every edge in the graph connects a variable node (in the first set of vertices) to a parity

node (in the second set of vertices). If each edge is now associated with two costs/weights to represent travel in either direction of the edge, there is a quantifier for communication from variable nodes to check nodes and from check nodes to variable nodes as claimed.

> "renormalization of non-leaf variable nodes further comprises enumerating all check-nodes a which are connected to the non-leaf variable node;"

On page 4, Rüger teaches of being able to disregard node i and all edges connected to i after clamping a value to node i. This corresponds to changing the bias weights w_{oj} by $s_i w_{ij}$ of all the nodes that share an edge with node i. Since in a bipartite graph (of Tanner), nodes from one set (check nodes) can only be adjacent to nodes in the other set (variable nodes), in order to change the bias weights of nodes that share an edge with i, the check nodes adjacent to i must be counted/listed/selected so that their common edge with i may be updated.

> "enumerating all other variable nodes j attached to the check node a"
>
> "transforming the numbers q_{aj}"

On page 11, Rüger teaches of Corollary 4.2. That states that if a node a1 is connected with nodes a2 and a3, then a1 can be decimated and the interaction mediated by a1 is replaced by the insertion of the effective weight v'a2a3. Since presumably, a1 is a non-leaf variable node, and nodes a2 and a3 would therefore be check nodes, the interaction mediated by a1 could not be replaced by simply inserting the effective weight v'a2a3. This is because in bipartite graphs, two nodes of the same type (set) cannot be adjacent to one another. Here since both a2 and a3 are check

nodes, then this effective weight edge connecting the two cannot be inserted. Rather, one skilled in the art would want to reflect the mediated interaction by node a1 through the other variable nodes connected to the check nodes a2 and a3. This would be done so that the interaction between the two nodes would be able to be reflected by going through another intermediate variable node. Once the variable nodes connected to the check nodes are counted/listed/selected, the edges connecting these variable nodes to the involved check nodes may then be updated/transformed so that the interaction mediated by a1 could be maintained. One skilled in the art would also realize that since a single check node can be the combination of up to k variable nodes, it would be computationally simpler to broadcast the updated weight edge on all outgoing lines from the check nodes instead of doing it selectively.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to include the further teachings of Rüger with those of Tanner so as to even further define the operation of the decimation process. One skilled in the art would be motivated to do this to make the decimation process even more precisely defined. By having the process more precisely defined, the process will be able to be implemented in an even more exact order with expected actions and results.

4.8 In regards to claim 15,

Tanner teaches of the limitations of claim 1 as above including:

"selecting a set of criterion by which to evaluate error-correcting codes"

In lines 57-65 of column 3, Tanner teaches of providing "a technique ... for implementing codes having quality comparable to, and in some case, superior to, that of

the best known codes." By stating that his new codes are comparable to or superior to prior art codes, Tanner is clearly selecting a criteria in order to evaluate his codes.

"generating a plurality of error-correcting codes"

Tanner further teaches in lines 45-51 of column 7 that "the freedom of choosing the subcodes, the freedom in selecting the construction, and the potential for recursion all combine to enable a rich and infinite number of LCR codes to be built."

"searching the plurality of error-correcting codes for an optimal error-correcting code according to the set of criterion"

Tanner further teaches of selecting a connected bipartite undirected graph (See lines 13-17 of column 4). Tanner goes on to teach in lines 56-65 of column 8 that "not every bipartite graph is suitable for the construction of good LCR codes. ... The best codes are based on graphs in which all digits are, in some sense, maximally connected in a balanced way." By choosing a bipartite graph and then inspecting the graph to make sure it is "suitable for the construction of good LCR codes," Tanner is looking for a graph (and its related code) that will create the best code (according to a selected criteria).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the further teachings of Tanner with those of Rüger for the same reasons set forth in Claim 1 above. Tanner's further teachings expand upon the evaluation of error correcting codes of Claim 1 by further defining the way in which the codes are evaluated. One skilled in the art would want to combine the further teachings of Tanner with those of Rüger so that the evaluation process is more clearly

defined which would allow one skilled in the art to make valid evaluations of the various error correcting codes.

4.9 Claims 5 and 6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tanner (US Patent # 4,295,218) and Rüger (Efficient Inference and Learning in Decimatable Boltzmann Machines) as applied to claims 1 as above, and further in view of Mathworld (Mathworld website definitions of loop and bipartite graph).

Tanner and Rüger teach all of the limitations of claim 1 as above except:

"the bipartite graph is loop-free"

and

"the bipartite graph includes at least one loop"

By definition, a "graph loop" from Mathworld is a "degenerate edge of a graph which joins a vertex to itself." A loop is essentially an edge that connects a vertex with itself not passing through any other vertices. By definition, a "bipartite graph" from Mathworld is "a set of graph vertices decomposed into two disjoint sets such that no two graph vertices within the same set are adjacent." Bipartite graphs therefore have two sets of vertices, where no vertex from a first set shares an edge with another vertex in the first set. All edges join a vertex from the first set to a vertex in the second set. Therefore, it is impossible for a bipartite graph to contain a loop because a loop connects a vertex (from the first set) to itself (which is clearly still in the first set. From this, it is clear that a bipartite graph MUST be loop-free.

Since a bipartite graph MUST be loop-free from above, it is clear that it CANNOT have at least one loop.

It would have been obvious to one of ordinary skill in the art that the mathematical definitions of a bipartite graph and a loop clearly anticipate the limitations of claim 5 and reject the limitations of claim 6 as being contradictory.

4.10 Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Tanner (US Patent # 4,295,218) and Rüger (Efficient Inference and Learning in Decimatable Boltzmann Machines) as applied to claim 7 as above, and further in view of MacKay (Relationships between Sparse Graph Codes, July 2000).

Tanner and Rüger teach all of the limitations of claim 7 as above, except:

> "representing the hidden variable bits by hidden nodes in the bipartite graph"
>
> and
>
> "defining the error-correcting code by a generalized parity check matrix wherein columns represent variable bits and rows define parity bits, and wherein an overbar is placed above columns representing hidden variable bits which are not transmitted"

Under the Section 4 heading "Generalized parity-check matrices" in column 2 on page 3 and lines 1-10 of column 1 on page 4, MacKay teaches of parity check matrices and generalized parity check matrices. "In a parity-check matrix, the columns are transmitted bits, and the rows are linear constraints. In a generalized parity-check matrix, additional columns may be included, which represent state variables that are not transmitted. ... The notation for state variables is a horizontal line above the corresponding columns."

Rüger does teach of hidden nodes being in Boltzmann machines, but does not state what variables the hidden nodes represent.

It would have been obvious to one of ordinary skill in the art at the time the invention was made would replace Tanner's and Rüger's parity check matrix with MacKay's generalized parity check matrix. One skilled in the art would do this so as to be able to create a way to relate sparse graph codes (which are a subset of linear codes described as graphs) to each other, as MacKay suggests in column 2 of page 3. By doing this, one skilled in the art would be able to evaluate the performance of linear codes with those of the special case sparse graph codes such as Convolutional codes, Product codes, and Turbo codes. Being able to evaluate the different performances of the codes would allow one skilled in the art to choose an appropriate code for his or her application.

4.11 Claim 14 is rejected under 35 U.S.C. 103(a) as being unpatentable over Tanner (US Patent # 4,295,218) and Rüger (Efficient Inference and Learning in Decimatable Boltzmann Machines) as applied to claim 4 above, and further in view of Chung et al (Analysis of Sum-Product Decoding of Low-Density Parity Check Codes using a Gaussian Approximation, February 2001).

Tanner and Rüger teach all of the limitations of claim 4 as above, except:

> "the transmission channel is an additive white Gaussian noise channel, and further comprising: representing messages between nodes in the bipartite graph by Gaussian distributions"

In the abstract on page 657, Chung teaches of AWGN channels and how Gaussian distributions are used to approximate message densities in sum-product decoders to simplify the analysis of the decoding algorithm.

It would have been obvious to one of ordinary skill in the art at the time the invention was made would combine Chung's AWGN teachings with those of Tanner and Rüger so as to be able to apply their methods to AWGN channels. As taught by Chung, one skilled in the art would want to use Gaussian distributions to approximate message densities because "density evolution is too complicated to be analyzed" (paragraph 3 column 2 page 657) for AWGN channels and that "without much sacrifice in accuracy, a one-dimensional quantity, namely, the mean of a Gaussian density, can act as a faithful surrogate for the message density, which is an infinite-dimensional vector." (paragraph 4 column 2 page 657) By using Gaussian distributions, one skilled in the art would be able to simplify the analysis and allow one to be able to study the characteristics of an AWGN channel without losing too much accuracy.

4.12 Claim 17 is rejected under 35 U.S.C. 103(a) as being unpatentable over Tanner (US Patent # 4,295,218) and Rüger (Efficient Inference and Learning in Decimatable Boltzmann Machines) as applied to claim 1 above, and further in view of Luby et al (US Patent # 6,073,250).

Tanner and Rüger teach all of the limitations of claim 1 as above, except:

"evaluating an error rate for the renormalized bipartite graph"

In lines 47-51 of column 20, Luby teaches that "Figure 23 depicts the results obtainable utilizing the error correction technique described above. There error rate,

i.e., the probability that a bit is corrupted and therefore has been flipped has been plotted against the failure rate, i.e., the rate at which the above-described technique fails to converge upon the correct solution within the given threshold… ." Luby is essentially teaching that one can calculate the error rate of an error correcting code

It would have been obvious to one of ordinary skill in the art to insert Luby's teachings to the end of Tanner and Rüger's method so that the error rate of the code represented by the decimated graph could be determined. One skilled in the art would want to do this so as to be able to compare the error rate of the code represented by the full, non-decimated graph with that of the code represented by a decimated graph. This would be a valuable step in determining if the code represented by the decimated graph still maintained the effectiveness of the error rate of the original code.

Allowable Subject Matter

5.1 Claims 8-11 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

6.1 The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Tanner's 1981 IEEE article teaches Tanner graphs and parity check matrix representation. Tanners 2000 article teaches more about parity check matrices. Rüger's 1997 article teaches of Boltzmann machines and further teaches decimation techniques. Richardson et al teach of bipartite graphs and their relationship to parity check matrices.

6.2 Any inquiry concerning this communication or earlier communications from the examiner should be directed to Marshall S. Eng whose telephone number is (703)305-4638. The examiner can normally be reached on M-F, 9:00 am to 5:30 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Albert DeCady can be reached on (703)305-9595. The fax phone number for the organization where this application or proceeding is assigned is (703) 305-3718.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703)305-3900.

mse

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